

# **Bioculture System Validation**

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# Bioculture System Objectives

1. Provide academia and industry with an incubator system on ISS that provides automated stable and selectable environment conditions to conduct a diversity of space flight experiment for cellular and microbiological research
  2. Provide an incubator that carries independent biospecimen cultures that are individually housed and accessible to the Crew for manual operations, and hardware refurbishment
  3. Provide a system compatible with numerous types of cell cultures and microbiological specimens up to a BSL-2 safety level and Toxicity level 2
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1. Support 30 – 60 day duration experiments and time course driven experiments
  2. Provides the capability to maintain a sterile environment for culturing biospecimen under automated and manual operations

# Biological Specimens Supported

Single cell type cultures, co-culture, infection, beads

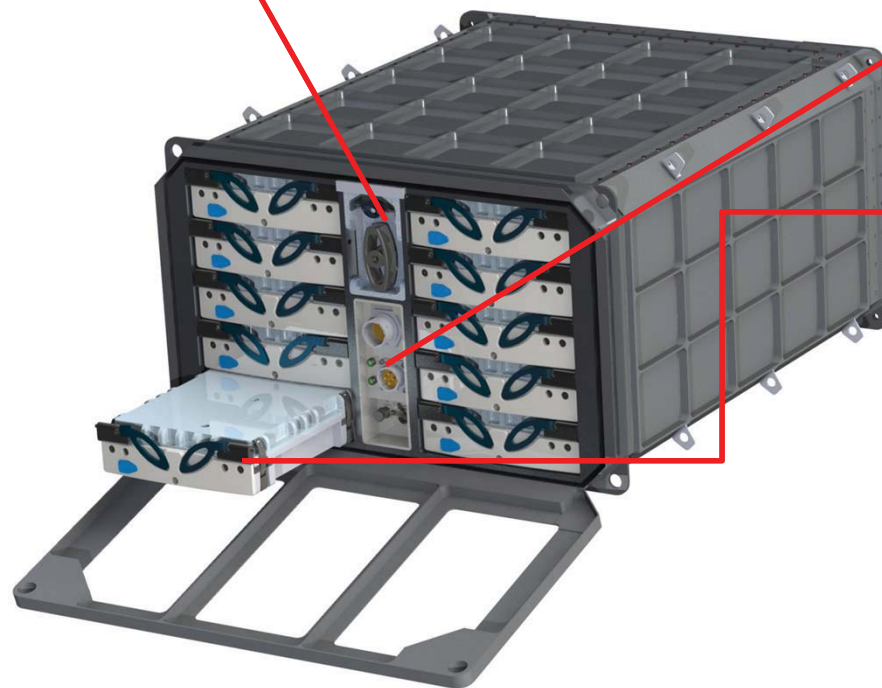
- Mammalian and non-mammalian Cell Cultures
  - Primary, Immortal, Tumorigenic, Explant
  - Stem Cells
  - 3-D Tissue Cultures
- Microbes
  - Bacteria
  - Yeast
- Miscellaneous small eukaryotic organisms

# Bioculture System

(NASA, Tissue Genesis Inc, Lockheed Martin)

Gas Supply  
Assembly

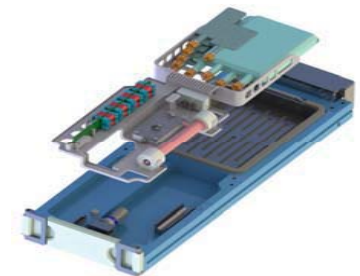
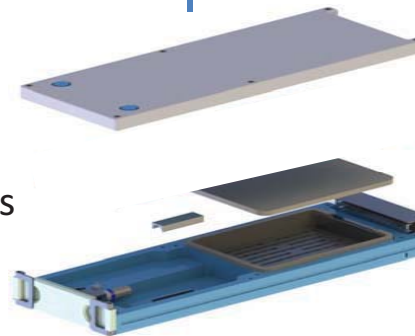
Power Supply  
Module



CASSETTE ASSEMBLY

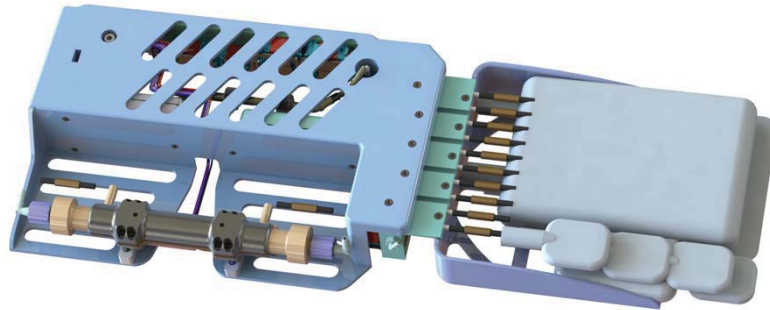
CASSETTE DURABLE  
ASSEMBLY

DISPOSABLE  
FLOWPATH ASSEMBLY

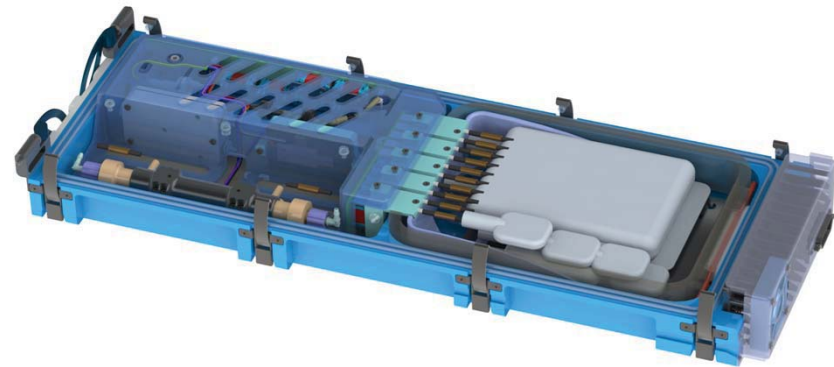


- 10 functionally independent Cassettes
  - Removable for on-orbit specimen processing
- Three levels of containment for liquid and particulates
- Replaceable gas supply
- Power – compatible with Dragon and ISS Express Racks
- Data telemetry and commanding

# Cassette



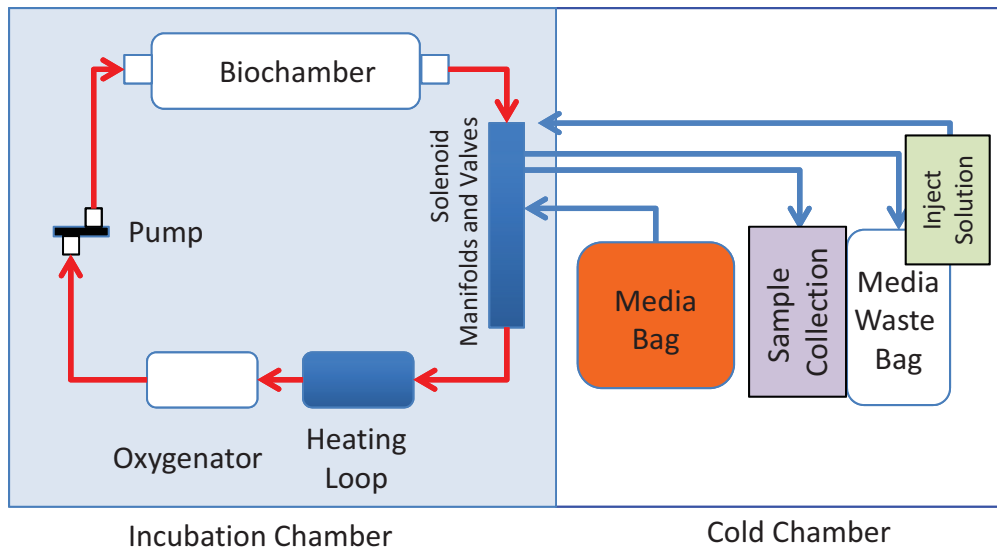
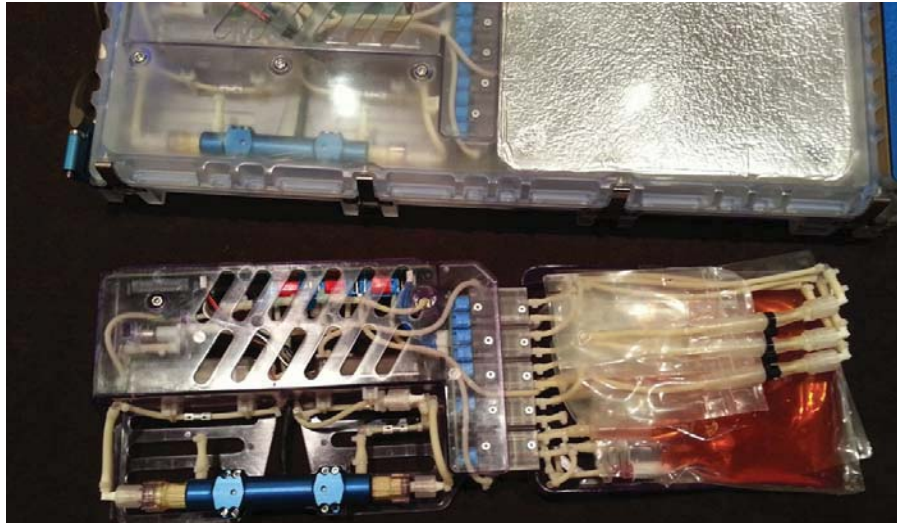
Experiment disposable insert



Experiment disposable fitted in cassette

- Self contained experiment with all preconfigured flowpath elements:
  - Bioreactor, pump, oxygenator, selector valves, medias, injectables
- Mates with cassette durable for power, temperature control (incubator/refrigerator), communication and feedback/parameter control
- Experiment parameter SD card travels with the disposable (identification and protocol)
- Rapid initiation and/or replacement of completed experiment disposable
- Multiple experiment replicates flown in cold storage for short duration experiments, backups, follow on experiments during flight increment

## Flow Path Schematic



Can multiplex to add a  
Second Biochamber

Up to a total of 10 sample  
and/or injection bags

### SUMMARY OF KEY CAPABILITIES

- Perfusion-based medium delivery
- PI-selected temperature set points
  - Cold chamber for stowage (ambient to +5oC)
  - Incubation chamber (Ambient to +42oC)
- Pre-programmed fluid flow rate (0 to 15 ml/min)
- Pre-programmed fluid replacement modes
- Medium oxygenation system
- Medium warming loop
- Automated sampling
- Automated solution injection
- Crew accessible
- Replaceable on-orbit
- All bags are replaceable on-orbit
- Access to the biochamber for initiation of cultures and subculturing on-orbit



# Bioculture System Validation

- Launch Bioculture System powered on SpX-5
  - Live active cell cultures delivered to ISS
  - Engineering test initiated at the time of launch
- Conduct on-orbit operations during Inc. 40 and Inc. 41
  - Cell culturing
  - Engineering check out and tests
  - Operations – on-orbit Crew ops, data telemetry, and commanding
- Return Bioculture System powered on SpX-5
  - Live active cell cultures delivered to ISS
  - Engineering test continue through hardware return to NASA ARC
  - Return temperature sensitive preserved samples in JSC Cold Stowage and the Bioculture System
- Nominal support hardware turn over at JSC at L-4 weeks
- Pre-flight operations at KSC – Late turn over at NET L-24 hours
- Ground control conducted at NASA ARC



**Goal:** Validate that the functionality of the Bioculture System to support the maintenance of cell culture on ISS and certify its readiness to support future space bioscience experiments by conducting biological, engineering, and operational tests of the System

**Objectives:**

**Biology.** The Bioculture System shall deliver and maintain viable cell cultures under characterized conditions and preserve cells for post-flight analyses for the duration of the mission.

**Engineering.** The Bioculture System shall operate as an incubator system for cellular and microbiological ISS research with automated capabilities to provide selectable environmental conditions.

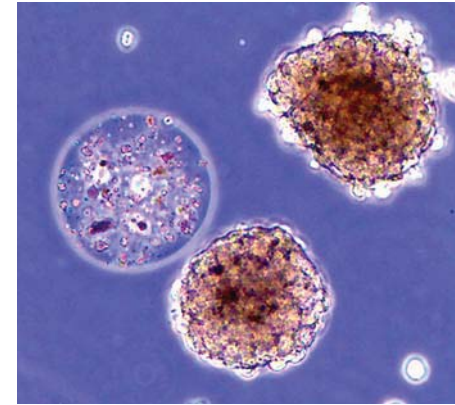
**Operations.** The design of the Bioculture System shall permit the successful completion of on-orbit operations, such as routine maintenance, and experiment-specific tasks.

## Biology Validation – 8 Cassettes

### 1) Human iCardiomyocytes (Cellular Dynamics)

#### Long Duration Culture

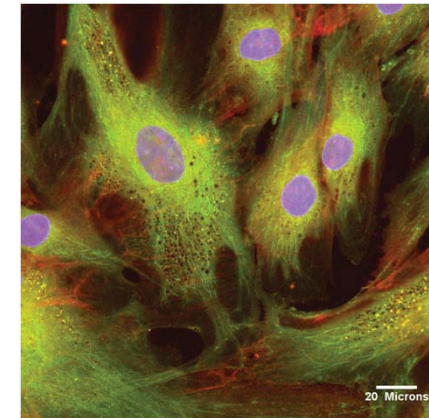
- 30 day culturing with 2 time points for automated sampling into RNALater-containing bags time points
- Crew-conducted procedure in the MSG to remove samples for freezing in MELFI
- Return specimens alive
- Post-flight analysis of gene expression, cell viability, cell morphology/physiology, medium composition and quality



### 2) Adipose Tissue-Derived Stem Cells (liposuction donor)

#### CCM Heritage Cell Culture

- Preservation by flooding the bioreactor with RNALater at 2 to 3 time points
- Return specimens alive
- Post-flight analysis of gene expression, cell viability, cell morphology/physiology, medium composition and quality

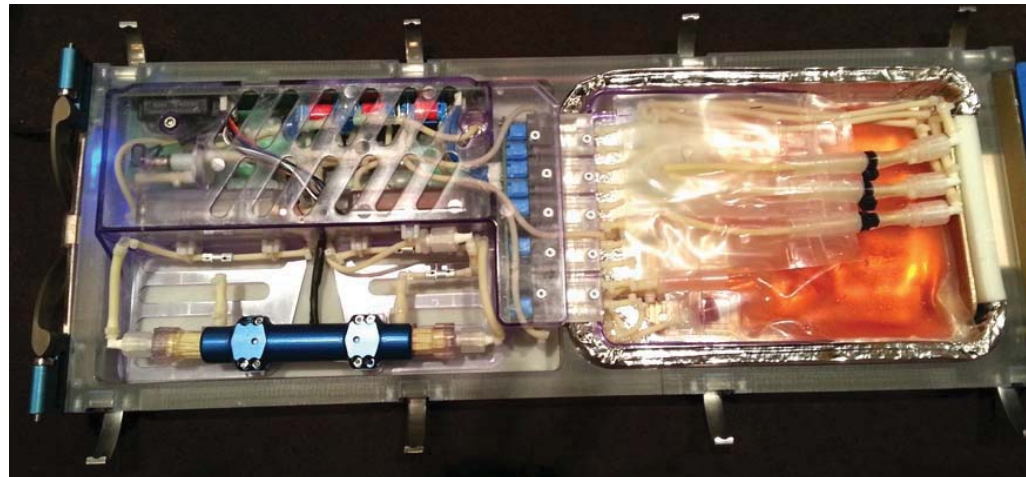


## Engineering Validation – 2 Cassettes

### Engineering health and status data from science cassettes

Exercise and characterize all automated capabilities and engineering functions

- 1) Character the performance of the Bioculture System during from launch to berth and unberth to return
- 2) Test and characterize automated activities – sampling, injection, fluid circulation
- 3) Test and characterize temperature ramping and reduction in the incubation chamber and cooling chamber
- 4) Test and characterize temperature recovery after power outage
- 5) Characterize gas delivery and maintenance
- 5) Characterize data collection, telemetry, and commanding implementation



## Operations Validation – Shared Cassettes with Science and Engineering

- 1) Characterize Cassette Crew procedures and processes for manual processing of the Cassette in the MSG by removing specimen-filled bags for transfer to MELFI
- 2) Characterize Crew procedure and process for the change out of the Gas Supply Assembly
- 3) Exercise the Bioculture System data telemetry function
- 4) Exercise and characterize ground command



Quick Seal Tubing



## Bioculture System Team

NASA ARC ISS Utilization Office

NASA ARC Space Biosciences and Space Biology

Lockheed Martin, NASA Ames Research Center

Tissue Genesis, Inc (HI)